Vulture observations in the Sahelian zones of Chad and Niger

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Observations de vautours dans la zone sahélienne au Tchad et au Niger. Nous présentons un résumé de l'ensemble des observations de vautours obtenues lors d'inventaires sur la faune sauvage effectués entre 2010 et début 2013 au Niger oriental et au centre du Tchad. Ces inventaires n'étaient pas restreints aux routes, ni destinés en premier lieu au suivi des rapaces, ce qui signifie que la comparaison avec des estimations précédentes est limitée. Toutefois, la totalité des fréquences d'observations de vautours (oiseaux / 100 km) est tout à fait similaire à celles citées pour le Sahel occidental en 2004. Le Vautour de Rüppell *Gyps rueppelli* est l'espèce la plus souvent observée ; des exemples de nidification arboricole de cette espèce et du Vautour oricou *Torgos tracheliotos* dans de nombreux endroits du Sahel sont donnés. L'importance des aires protégées sahéliennes pour les populations reproductrices de ces deux espèces est documentée et la forte exposition des vautours à la pression anthropique et leur contribution au niveau des services écosystémiques sont évoquées. Par ailleurs, des informations essentielles sont fournies sur les fréquences d'observations actuelles de vautours, qui sont en principe reproductibles à l'avenir.

Summary. We present a summary of all vulture encounters during a series of wildlife surveys conducted in eastern Niger and central Chad, between 2010 and early 2013. These surveys were not restricted to roads and not designed primarily for raptor surveys, so comparaison with earlier estimates is limited, but overall vulture encounter rates (birds / 100 km) were broadly similar to those reported in the western Sahel in 2004. Rüppell's Vulture *Gyps rueppelli* was the most frequently observed species and examples of tree-nesting by this species and Lappet-faced Vulture *Torgos tracheliotos* in widely separated parts of the Sahel are summarised. The importance of Sahelian protected areas for breeding populations of these two species is documented, the strong exposure of vultures to human influence and their contribution to ecosystem services are discussed, while baseline information on current vulture observation rates, in principle repeatable in the future, is provided.

Recent studies of raptor road count information from a large area of West Africa have revealed a substantial decline in nearly all resident species over the past 30–40 years (Rondeau & Thiollay 2004, Thiollay 2006a, BirdLife International 2011, 2012). Vulture encounter rates in road counts are reported to have declined by 94% outside protected areas in the Sahel during this period (Thiollay 2006b). In view of this, all vulture and raptor observations have been consistently recorded during a series of extensive wildlife surveys and monitoring work by the Sahara Conservation Fund (SCF) and its partners in Chad and Niger. Regular recording commenced in the Termit area of Niger in 2007 and has since been expanded across both countries via a series of surveys at additional locations from late 2010 to early 2013.

In collaboration with Niger's Direction de la Faune, de la Chasse et des Aires Protégées (DFCAP), dry-season surveys have been conducted at Gadabeji Game Reserve, which was formally protected as a forest and wildlife reserve in 1955, and in the Gadafaoua-Taguedoufat region, an unprotected area under consideration as a managed hunting block. At Termit Massif and the adjacent Tin Toumma desert, the Sahelo-Saharan Antelope project has worked closely with the Nigerien wildlife department to establish a new protected area, the Termit and Tin Toumma National Natural Reserve (RNNTT), which was formally gazetted in March 2012.

In Chad, in collaboration with the Direction des Parcs Nationaux, Réserves de Faune et de la Chasse (DPNRFC), a wet-season survey was conducted in the Manga and Eguey regions, which although not formally protected support important wildlife populations. A further four surveys, covering both wet and dry seasons, were undertaken in the Ouadi Rimé-Ouadi Achim Game Reserve (OROAGR), which has been legally protected since 1969. Together these surveys provide data from a large zone across both Niger and Chad, stretching *c.*1,500 km east to west by *c.*500 km north to south (Fig. 1). In all, 35 half-degree grid squares were visited in Niger and 86 in Chad. This paper summarises information on the relative abundance, distribution and breeding

behaviour of the six vulture species seen during field work. The area covered complements that surveyed in Mali, Burkina Faso and Niger in the 1970s and 2004 (Thiollay 2006a,b) (Fig. 1). Spot records of vultures in western Chad reported by Scholte (1998) appear to be mostly located in the south or further south than the zone reported here. Thus our results extend recent information on vulture distribution and status across the Sahel, although differences in methods and location mean our results are not directly comparable.

Methods

All vultures observed, in flight or on the ground, were recorded by species, number of individuals, time, location and activity. Methodology was broadly similar to that employed for monitoring raptors in extensive road count surveys in West Africa (Thiollay 2006a,b). However, they are not wholly comparable, because the surveys reported here were designed primarily for large mammal and land use recording at specific locations, with raptor counts added throughout as a secondary activity. Observations were made by at least four observers working from two vehicles travelling in single file and communicating via short-range radio. Activities during raptor counts included travel on asphalt, off-road reconnaissance, and off-road navigation of systematic straight-line transects to survey large areas (typically 6–8 parallel 40-km transects spaced at 10-km intervals), collecting data on large terrestrial mammals, bustards, livestock and human activity. Periodic, 500-m foot transects (+ / - every 10 km) were also conducted on transect sectors. Further variation in observation conditions arose because not all areas could be visited at the same time of year or during vulture breeding periods (primarily December–April). All vultures and other raptors seen were recorded irrespective of survey activity (including at stops), with vehicles stopped to verify identification and activity details with binoculars and photographs where necessary. Observations were recorded and automatically logged in a standardised format via a hand-held computer incorporating GPS using Cybertracker© software (www.cybertracker.org).

Information from Termit / Tin Toumma differs qualitatively in that most observations were made during repeated 10–14-day surveys and monitoring visits at 2–3 month intervals over the period 2008–11. Survey teams comprised several different observers and recorders. At all other sites, surveys were typically of *c.*2–3-weeks duration, conducted by the same core team members with the same recorder present on all occasions and widely separated by season during the period 2010 to early 2012.

Because the surveys were not aimed solely at raptor counting, have not been divided into sample units with respect to raptor distribution and were conducted under varying conditions, detailed statistical comparison of encounter rates is avoided. Nevertheless, simple encounter rates (birds / 100 km) have been calculated as a very broad guide. Interpretation and comparison must be subject to the caveats indicated above.

Landscapes and habitats

The surveys visited a wide range of tropical Sahelian and Saharan habitats between 12.00°–17.50°N. With the exception of routine monitoring at volcanic outcrops, plateaux and valleys of the Termit Massif, most landscapes surveyed comprised relatively wide, flat plains or undulating fixed dunes characteristic of the ancient greater Lake Chad Basin and its margins. The most southerly routes (in Chad) traversed the transition zones between Sahelian grasslands and light woodlands of the northern Sudan savannahs. The greater part of survey time was spent in the Sahel, with significant excursions into the southern Sahara in Tin Toumma (Niger) and Eguey (Chad). At Gadabeji in Niger and in the Chadian Manga and Ouadi Rimé-Ouadi Achim, typical Sahelian grassland plains and areas of vegetated fixed dunes predominate. Important tree species with respect to vulture observations include *Sclereocarya birrea* (Gadabeji), *Balanites aegyptiaca*, *Acacia raddiana* and *Maerua crassifolia* (all locations). Among fixed dunes, such as those at Gadabeji and in the southernmost Ouadi Rimé-Ouadi Achim reserve, trees may form small thickets. On flatter ground, isolated trees are more characteristic. Vegetation generally diminishes and trees disappear entirely at more northerly latitudes, especially across the large exposed dunes of the vast Tin Toumma and the flatter sandy ground of Eguey. Bahr al Ghazal, a former drainage of the drying Lake Chad, provides a distinctive habitat feature running diagonally north-east to south-west across central Chad,

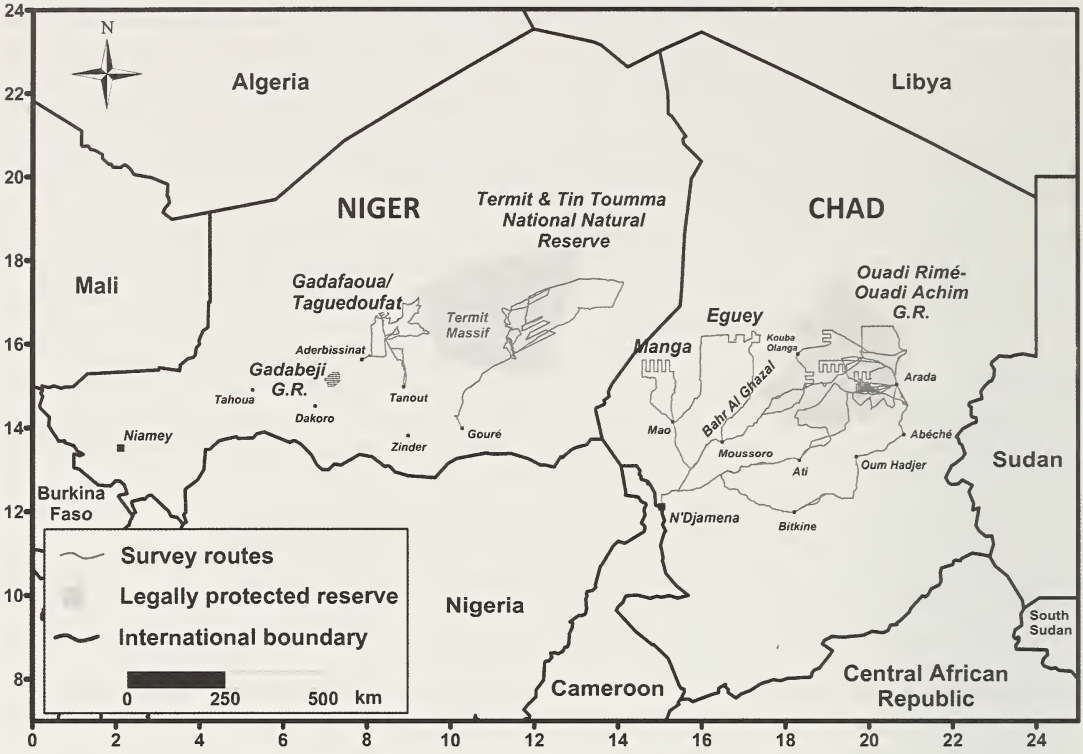

Figure 1. Map of survey routes in Niger and Chad where vulture observations were made in relation to major protected areas in the region. Note only two selected routes are illustrated in the Termit Tin Toumma area for clarity—see text.

Carte des itinéraires de comptage au Niger et au Tchad où des observations de vautours ont été faites, par rapport aux principales aires protégées de la zone. Noter que seulement deux itinéraires sont indiqués pour la zone de Termit et Tin-Toumma par souci de clarté—voir texte.

distinguished by numerous trees and thickets, e.g. of *Acacia nilotica* and *Salvadora persica*. Following rain (July–September) numerous temporary pools form along the Bahr al Ghazal, although at other seasons the area is dry and dusty.

Distribution and availability of potential food resources for vultures across the survey area is dictated primarily by the presence and movements of livestock. The overall relative abundance and biomass of livestock substantially outstrips that of wild ungulates everywhere except in Termit / Tin Toumma. Among wild ungulates, only Dorcas Gazelle *Gazella dorcas* occurs throughout, with significant numbers at Termit in Niger, and in the Manga and Ouadi Rimé-Ouadi Achim in Chad. Only at Termit do wild ungulates (mostly Dorcas Gazelles with very small numbers of Dama Gazelle *Nanger dama*, Barbary Sheep *Ammotragus lervia* and Addax *Addax nasomaculatus*) match or locally surpass domestic livestock in abundance and diversity. In all other areas, very large and mobile herds of camels, cattle and small stock with attendant donkeys and horses are widespread, based primarily around extensive wells at more southerly latitudes. Transhumance in search of fresh grazing and surface water with seasonal rainfall still operates over much of the region, resulting in significant seasonal movements of people and their herds.

Results

Six species of vulture were encountered along the routes illustrated in Fig. 1. The primary survey areas, with dates and season, a brief indication of survey method, habitat and overall effort (days in the field, total distance covered and number of half-degree squares entered), and total numbers of locations where vultures were seen at tree nests, are

Table 1. Summary of vulture sightings and survey effort during Pan-Sahara Wildlife Surveys, Chad and Niger 2010–12 and the Sahelo-Saharan Antelope project at Termit Massif accumulated 2007–11. Figures under the species columns indicate total number of birds seen with total number of locations with birds on tree nests in square brackets.

Tableau 1. Résumé des observations de vautours et de l'effort de comptage lors des inventaires du Pan-Sahara Wildlife Surveys au Tchad et au Niger en 2010–12 et dans le cadre du projet Antilopes Sahélo-Sahariennes au massif de Termit en 2007–11. Les chiffres sous les colonnes des espèces indiquent le nombre total d'oiseaux observés, avec (entre parenthèses) le nombre total des localisations concernant des oiseaux nichant dans des arbres.

Location	0.5 × 0.5 grids visited [days in the field]	Survey period	Habitat	Survey methods	Egyptian Vulture *Neophron percnopterus*	Hooded Vulture *Necrosyrtes monachus*	White-backed Vulture *Gyps africanus*	Rüppell's Vulture *Gyps rueppelli*	Lappet-faced Vulture *Torgos tracheliotos*	White-headed Vulture *Trigonoceps occipitalis*
Gadabeji, Niger	1 [16]	Mar 2010	Sahel grassland. Plains and fixed dunes, trees frequent	Off-road vehicle transects (376.5 km)	2	0	0	16 [5]	9[2]	3[1]
Gadafaoua-Taguedoufat, Niger	9 [15]	May 2010	Gadafaoua: gravel plains, rocky outcrops, barkans, trees infrequent / absent. Taguedoufat: Sahel grassland and gravel plains, trees infrequent	Off-road vehicle reconnaissance (1,078 km)	0	0	0	0	10[1]	0
Termit/Tin Toumma, Niger	24 [multiple visits]	2007–11	Sahel fixed-dune grassland (trees frequent); sub-Saharan massif, sand & gravel valleys, cliffs & plateaux (trees frequent), Tin Toumma: Saharan sand sea desert (trees absent)	Routine monitoring at three-month intervals. Off-road reconnaissance and fixed transect surveys.	(43 sightings)	0	0	[1]	(Near-daily sightings at Termit Massif) [80]	0
Manga and Eguey, Chad	24 [14]	Aug 2010	Manga: Sahel fixed-dune grassland (trees frequent). Eguey: sub-Saharan gravel and sand-sheet plains (trees absent)	Off-road reconnaissance and transects (1,937 km): road count (332 km)	0	29	17	140+ (+50 *Gyps* sp.)	35	0
Central Chad and RFOROA	39 [19]	Jan–Feb 2011	Ndjamena to Arada Sahel/Sudan margin (trees abundant), RFOROA: Sahel grassland, trees frequent to scarce	Road count and off-road transects and reconnaissance 3,300 km	10	18	18	77[3]	17[3]	1
Central Chad and RFOROA	47 [20]	Sep 2011	"	Road count and off-road transects and reconnaissance 3,027 km	4	45	16	122	52	0
Central Chad and RFOROA	35 [10]	Apr 2012	"	Road count and off-road reconnaissance 2,028 km	1	16	0	24[2]	15[4]	0
Central Chad and RFOROA	39 [18]	Mar 2013	"	Road count and off-road reconnaissance 2,827 km	25	3	4	193[13] (+28 *Gyps.* sp.)	67[10]	0

Table 2. Vulture encounter rates in eastern Niger and central Chad, 2010–12, summing all surveys except Termit / Tin Toumma. Total distance covered: 14,905 km. See Fig. 1 and Table 1 for details.

Tableau 2. Fréquence d'observations des vautours au Niger oriental et au centre du Tchad, 2010–12, pour tous les inventaires cumulés à l'exception de ceux dans le Termit et Tin-Toumma. Distance totale parcourue : 14.905 km. Voir Fig. 1 et Tableau 1 pour plus de détails.

Species	Total seen	Encounter rate: birds / 100 km
Egyptian Vulture *Neophron percnopterus*	42	0.3
Hooded Vulture *Necrosyrtes monachus*	111	0.7
White-backed Vulture *Gyps africanus*	55	0.4
Rüppell's Vulture *Gyps rueppelli*	572	3.8
Lappet-faced Vulture *Torgos tracheliotos*	205	1.4
White-headed Vulture *Trigonoceps occipitalis*	4	0.03
Unidentified *Gyps*	87	0.6
Total	1,076	7.2

summarised in Table 1. Overall encounter rates are summarised in Table 2. Notes on individual species are given below, with present conservation status (BirdLife International 2012). All six species are currently either EN = Endangered or VU = Vulnerable.

Egyptian Vulture *Neophron percnopterus* (EN)
Recorded in 20 of 121 half-degree squares (Fig. 2), with a cluster of regular encounters in the Termit Massif and Koutous hills (*c.*120 km south-west of Termit) in Niger, where the presence of adults and

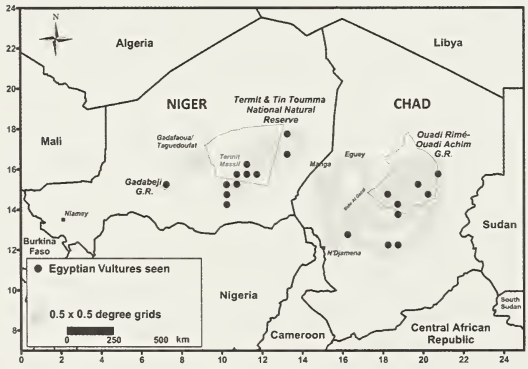

Figure 2. Distribution of Egyptian Vulture *Neophron percnopterus* observations. Grey = grid squares visited during survey work.

Distribution des observations de Vautour percnoptère *Neophron percnopterus*. Les carrés parcourus lors des travaux d'inventaires apparaissent en gris.

occasional immatures year-round (except January and April) implies a resident population. Nests yet to be found. Dry-season sightings of pairs at the rocky outcrops of Dibella and Agadem, east of Tin Toumma in Niger (November 2010), are also notable. These remote hills are surrounded by extensive treeless sand desert but align to the north with a series of outcrops running north to south across the central Sahara. It is unclear whether the vultures here are residents, migrants, or opportunistic followers of nomads and their livestock temporarily based at the ancient wells and scattered clumps of *Hyphaene* palms that grow in the lee of the hills. Elsewhere observations mainly of immatures in ones and twos across the grasslands of central Chad are typically associated with multi-species gatherings at livestock carcasses. Notable concentrations of nine in February 2011 and 22 (adults and immatures) in March 2013 were at the southern end of the Bahr al Ghazal, with other vultures at the same water-filled roadside borrow pit. This area corresponds closely to the first resting area (seven days in October–November 2001) used by a satellite-tracked immature captured as a nestling in Bulgaria (Meyburg *et al.* 2004). In the 1960s a seasonal population of 400 comprising 50% Palearctic migrants and 50% African residents was estimated at Abéché (Salvan 1968), but none was noted there in three separate visits by us. Recent studies confirm regular overwintering in the Sahel by European-breeding Egyptian Vultures (Ceccolini *et al.* 2009, García-Rippolés *et al.* 2010). Resident breeding has been confirmed infrequently at a few scattered localities in the Sahel (Salvan 1968, Scholte 1998, Thiollay 2006b) and there is evidently interesting potential for direct contact and exchange between resident African and migrant European stocks.

Hooded Vulture *Necrosyrtes monachus* (EN)
Observed in 16 of 121 half-degree squares, primarily in the southernmost part of the survey area closer to more Sudan savannah habitats. The main concentration is associated with the comparatively well-watered zone at the southern end of the Bahr al Ghazal in Chad (Fig. 3). Most were near or over villages and towns, in line with its well-known commensal habits in West Africa (Brown *et al.* 1982). Northernmost sightings in

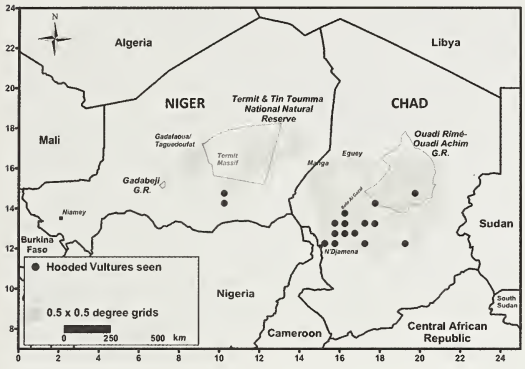

Figure 3. Distribution of Hooded Vulture *Necrosyrtes monachus* observations. Grey = grid squares visited during survey work.

Distribution des observations de Vautour charognard *Necrosyrtes monachus*. Les carrés parcourus lors des travaux d'inventaires apparaissent en gris.

the Ouadi Rimé-Ouadi Achim Game Reserve were in the wet season, but no evidence of nesting anywhere. Breeding at more northerly latitudes of Niger and Chad is known (Brown *et al.* 1982, Borrow & Demey 2001); the species was present in hundreds at Abéché in the 1960s, associating with an abattoir (Salvan 1968). Our surveys passed this town in both wet and dry seasons, but none was recorded there. Throughout the 1970s Hooded Vulture was an uncommon, mainly wet-season visitor to the OROAGR, with no breeding records in the reserve (Newby 1979).

White-backed Vulture *Gyps africanus* (EN)
Encountered in nine half-degree squares, all in Chad, and primarily in the wet season at the Bahr al Ghazal (Fig. 4). Principally associated with the Sudanian zone at the southern margins of the study area (Salvan 1968, Brown *et al.* 1982, Borrow & Demey 2001) and was considered resident and common to abundant in the early 1990s by Scholte (1998). The majority of sightings were in the south, but the surveys also revealed that a small number may move north in the wet season. Two were recorded north of 14°N in the western Ouadi Rimé-Ouadi Achim, in an area with numerous temporary pools, in September 2011. Largest numbers in the southern Bahr al Ghazal with many raptors and other large soaring birds attracted to the temporary pools, insects and livestock in the area in September 2010. Usually observed in mixed-species assemblages with Rüppell's Vultures and sometimes Hooded and Lappet-faced Vultures, enabling direct comparisons. No evidence of breeding.

Rüppell's Vulture *Gyps rueppelli* (EN)
Recorded in 39 of 121 half-degree squares (Fig. 5), and in all seasons and zones, except Gadafaoua-Taguedoufat, which was visited only in the dry season. Rüppell's Vultures account for the majority of vulture observations in the survey area (Tables 1–2). Considered resident and common throughout the area by Scholte (1998). Active established vulture colonies on prominent

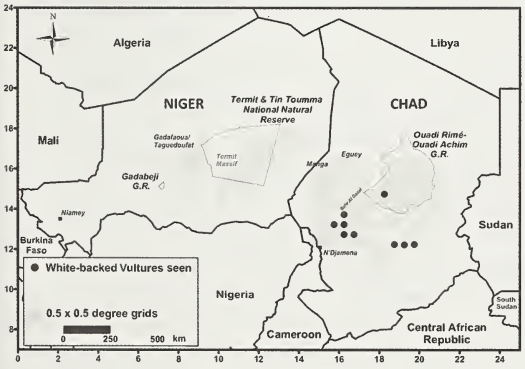

Figure 4. Distribution of White-backed Vulture *Gyps africanus* observations. Grey = grid squares visited during survey work.

Distribution des observations de Vautour africain *Gyps africanus*. Les carrés parcourus lors des travaux d'inventaires apparaissent en gris.

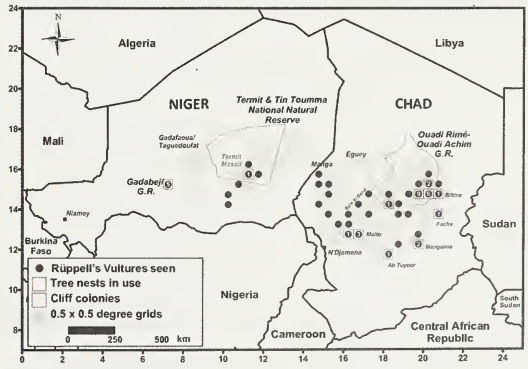

Figure 5. Distribution of Rüppell's Vulture *Gyps rueppelli* observations. Grey = grid squares visited during survey work.

Distribution des observations de Vautour de Rüppell *Gyps rueppelli*. Les carrés parcourus lors des travaux d'inventaires apparaissent en gris.

Figure 6. Example of typical cliff colony of Rüppell's Vulture *Gyps rueppelli* near Moito, central Chad, March 2013. At least six perched birds visible on upper margin of white-stained area (Tim Wacher)

Exemple typique de colonie de Vautours de Rüppell *Gyps rueppelli* sur les falaises près de Moito, au centre du Tchad, mars 2013. Au moins six oiseaux perchés sont visibles sur la bordure supérieure de la zone teintée de blanc (Tim Wacher)

Figure 7. Adult Rüppell's Vulture *Gyps rueppelli* and small chick (lower right and below) in *Balanites aegyptiaca* tree nest, Gadabeji, Niger, March 2010 (Tim Wacher)

Vautour de Rüppell *Gyps rueppelli* adulte et petit oisillon (en bas à droite et dans l'encart) sur un nid dans un *Balanites aegyptiaca*, Gadabeji, Niger, mars 2010 (Tim Wacher)

granite inselbergs across southern Chad were noted at Moito, Ab Tuyoor, Mangalme, Facha and probably Biltine in 2013 (Figs. 5–6). Time and survey objectives did not permit accurate counting at these sites, nor were any direct observations of active nests confirmed, although 47 of the total Rüppell's Vultures recorded on the 2013 survey were associated with these colonies. In addition 24 cases of Rüppell's Vultures using treetop stick nests at the height of the dry seasons of 2010–13 were recorded (for a summary of tree-nesting observations, see Table 3). The nests resemble tree nests of Lappet-faced Vultures in situation and structure, generally in the crowns of flat-topped thorny trees, though perhaps averaging slightly smaller in size. *Balanites aegyptiaca* trees were strongly favoured, used in all five cases at Gadabeji and in 14 of 18 nests in OROAGR (the rest were in *Maerua crassifolia*). At Gadabeji, in March 2010, white downy young of varying sizes were observed in three nests, with attendant adults present in all cases (Fig. 7). Adults were

Table 3. Vulture tree nests observed in Niger and Chad, 2008–13. In all cases nests were discovered by observing adult birds standing on the nest, confirming species identity.

Tableau 3. Nids de vautours arboricoles observés au Niger et au Tchad entre 2008 et 2013. Noter que les nids ont été découverts en observant des adultes perchés sur le nid, confirmant ainsi l'identité de l'espèce.

		Nest status		Nesting tree species				
		Nests	Eggs or chick confirmed	*Maerua crassifolia*	*Balanites aegyptiaca*	*Acacia raddiana*	*Sclereocarya birrea*	Tree sp.?
Termit	Lappet-faced Vulture	80	11*	34	1	45	0	0
	Rüppell's Vulture	1	0	1	0	0	0	0
Other sites	Lappet-faced Vulture	17	4	4	4	4	0	5
	Rüppell's Vulture	23	16	3	19	0	0	1
	White-headed Vulture	1	0	0	0	0	1	0
	Totals	122	31	42	24	49	1	6

* maximum number of chicks recorded in a single year (2011),when 53 nests were monitored consistently throughout the breeding season.

Figure 8. Adult Rüppell's Vulture *Gyps rueppelli* shading young on nest in *Balanites aegyptiaca* tree, Ouadi Rimé-Ouadi Achim Game Reserve, Chad, March 2013 (John Newby)

Vautour de Rüppell *Gyps rueppelli* adulte faisant de l'ombre à un oisillon sur un nid dans un *Balanites aegyptiaca*, Tchad, mars 2013 (John Newby)

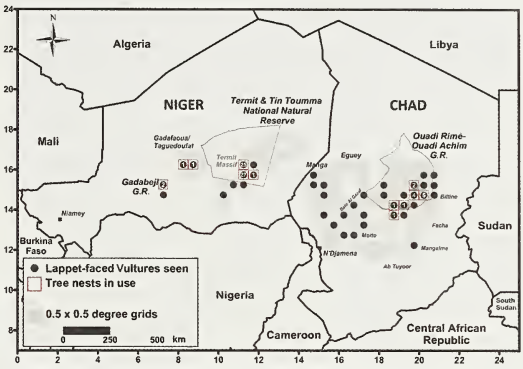

Figure 9. Distribution of Lappet-faced Vulture *Torgos tracheliotos* observations. Grey = grid squares visited during survey work.

Distribution des observations de Vautour oricou *Torgos tracheliotos*. Les carrés parcourus lors des travaux d'inventaires apparaissent en gris.

seen sitting tight at three tree nests in OROAGR in January 2011. Larger young, possibly recently fledged but still tended by adults, were observed at two tree nests in OROAGR in April 2012. At 13 tree nests found in OROAGR in March 2013 young were observed at 11 nests, in all cases with at least one adult shading the nestling (Fig. 8). Minimum distances between active nests were 3.6–5.6 km at Gadabeji, once with an active Lappet-faced Vulture nest 700 m away. Six nests at OROAGR in 2013 were <2 km from other active Rüppell's Vulture nests, with a minimum distance of 704 m between nests. One nest was 524 m from a Lappet-faced Vulture nest. No cases were observed of Rüppell's Vultures nesting in the same tree as Lappet-faced Vultures, as reported by Salvan (1968). In the southern OROAGR a small group of tree nests was noted in sight of granite inselbergs *c*.30 km to the south-east. A pair consistently visited a large stick nest in the crown of a *Maerua crassifolia* on the east side of the Termit Massif in 2008–10, although breeding was not confirmed. The species consistently attends livestock carcasses and sometimes wells in the southern RNNTT, occasionally in large groups (Fig. 14).

Lappet-faced Vulture *Torgos tracheliotos* (VU)
Widespread but not common in Chad in the early 1990s (Scholte 1998), this was the second-most frequently recorded species and by a narrow margin

Figure 10. Lappet-faced Vultures *Torgos tracheliotos* at nest on *Maerua crassifolia*, Ouadi Rimé-Ouadi Achim Game Reserve, Chad, March 2013 (John Newby)

Vautours oricou *Torgos tracheliotos* sur un nid dans un *Maerua crassifolia*, Réserve de Faune de Ouadi Rimé-Ouadi Achim, Tchad, mars 2013 (John Newby)

the most widespread, seen in 40 of 121 half-degree squares (Fig. 9). Breeders were observed at large stick nests in the crowns of trees at two sites in Gadabeji (March 2010). At OROAGR nests were found at one site in February 2011, four sites in April 2012 and ten sites in March 2013 (Fig. 10). Three of the ten nests in March 2013 were <2 km from other active nests and, unlike Rüppell's Vulture, most nests were on either *Acacia raddiana* or *Maerua crassifolia*, with only two on *Balanites aegyptiaca*. At both Gadabeji and OROAGR examples of Lappet-faced Vultures nesting <1 km

Figure 11. Pair of Lappet-faced Vultures *Torgos tracheliotos* on *Balanites aegyptiaca* tree nest, Termit, Niger, December 2007 (Tim Wacher)

Couple de Vautours oricou *Torgos tracheliotos* sur un nid dans un *Balanites aegyptiaca*, Termit, Niger, décembre 2007 (Tim Wacher)

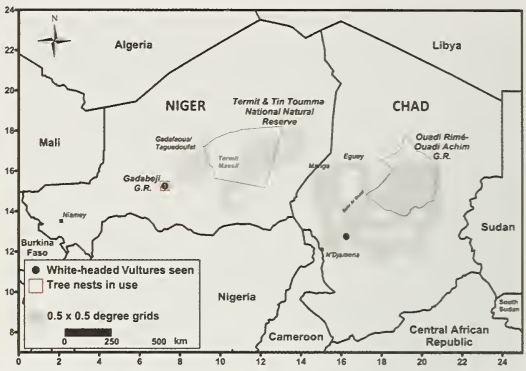

Figure 12. Distribution of White-headed Vulture *Trigonoceps occipitalis* observations. Grey = grid squares visited during survey work.

Distribution des observations de Vautour à tête blanche *Trigonoceps occipitalis*. Les carrés parcourus lors des travaux d'inventaires apparaissent en gris.

from Rüppell's Vulture tree nests were found (see above). In late May 2010, Lappet-faced Vultures were seen perched near large vulture tree nests at two locations in the central plains of the Gadafaoua region of Niger, and although nesting was not proven, it is highly probable.

The major breeding area detected is in the Termit Massif. In 2007–11, the SCF / DCFAP survey teams logged 80 active nests at Termit, with 45 on *Acacia raddiana*, one on *Balanites aegyptiaca* (Fig. 11) and 34 on *Maerua crassifolia*. Not all nests are used annually. Fifty-three nests were attended by adults in early 2011, of which at least 11 produced young. In most cases at Termit nests were not in view of each other at ground level, although a high proportion were within 2 km of one another. Salvan (1968) records multiple nests ('4 or 5') in one tree. Although some examples of new active nests were observed alongside old and collapsed nests in the same tree, all nest sites involve single pairs, and no cases of multiple active nests in one tree were encountered.

White-headed Vulture *Trigonoceps occipitalis* (VU)

Typically scarce compared to other species (Brown *et al.* 1982) and like Hooded and White-backed Vultures probably has a relatively southerly distribution compared to the main survey area. As might be expected, they were the least frequently encountered species in our dataset, being found in one half-degree grid square in each country (Fig. 12). A pair was observed on a large tree nest at Gadabeji, slightly north of published range limits, during a reconnaissance in January 2008 (Fig. 13); three single adults were seen separately in the same area in March 2010. It was considered a regular wet-season visitor to the vicinity of Abéché in the 1960s (Salvan 1968) and to be widespread and breeding during the cooler months in the Ouadi Rimé-Ouadi Achim reserve during the 1970s (Newby 1979). None was encountered during recent visits (wet and dry season) to OROAGR.

Figure 13. Pair of White-headed Vultures *Trigonoceps occipitalis* at *Sclereocarya birrea* tree nest, Gadabeji, Niger, January 2008 (Scott Tidmus)

Couple de Vautours à tête blanche *Trigonoceps occipitalis* sur un nid dans un *Sclereocarya birrea*, Gadabeji, Niger, janvier 2008 (Scott Tidmus)

Relative encounter rates

Simple global encounter rates (birds counted / 100 km) derived from summing all observations across all surveys outside the Termit region (see Methods) are summarised in Table 2. These show that the numerically most abundant species, Rüppell's Vulture, was observed at nearly 4 birds /100 km, followed by Lappet-faced Vulture at just less than 1.5 birds / 100 km. The global rate of vulture sighting combining all six species was 7.2 birds / 100 km.

Discussion

These observations provide a snapshot of the presence and breeding activity of vultures in the Sahelian grassland zones of eastern Niger and central Chad, primarily during the period 2010 to early 2013. Vultures were recorded in 61 of 121 (50%) half-degree squares visited, within a zone bounded by the Sudanian belt to the south and the Sahara to the north. Confirmed tree-nest breeding locations for Rüppell's and Lappet-faced Vultures were found in 13 half-degree grid squares spread widely through the survey region, with suspected breeding in a further two grid cells. In addition, indications of active Rüppell's Vulture colonies were observed around granitic inselbergs in at least eight locations visible from major roads in six half-degree squares in Chad. Breeding by White-headed Vulture was suspected at one location. In Niger, the Gadabeji Game Reserve (protected since 1955) and the newly created Termit Tin Toumma National Nature Reserve emerge as important locations for breeding vultures. In Chad, the eastern Ouadi Rimé-Ouadi Achim Game Reserve also supports important breeding sites for vultures. The Bahr al Ghazal, particularly its southern end, appears disproportionately well frequented by several vulture species, including migrant Egyptian Vultures, especially in the wet season when livestock concentrations are high. The absence of breeding records from the Chadian Manga, where one of the largest assemblages of vultures was encountered, is probably an artefact of visiting the area only in August 2010, when breeding is not expected. A dry-season survey of this area may change this picture. Finally, although we have experience of migrant Eurasian Griffon Vultures *Gyps fulvus* further west in sub-Saharan Africa, none was positively identified by us during these surveys.

The global encounter rates (Table 2) provide a very basic measure of relative abundance. While noting reasons for being cautious in comparing our data to those of dedicated road counts (see Methods), the combined encounter rate for all six species (7.2 vultures / 100 km) falls within the estimated range for comparative abundance for the same six species (7.9 vultures / 100 km + / - S.E. 2.3) based on 12 transects across the Sahel of Mali and western Niger in 2004 (Thiollay 2006b). This implies that vulture abundance may be broadly similar between the two regions. The figures from Mali and western Niger represent a >90% reduction since the early 1970s. Although we lack similar data from the 1970s from our study area, earlier descriptions of vultures of Chad (e.g. Salvan 1968) hint at the possibility of a similar trajectory. Scholte (1998) reported a more optimistic interpretation based on spot counts at carrion and waterhole assemblies in central Chad in the early 1990s, but these point data are not comparable with transect-based information.

The current study included significant areas away from roads and development, where traditional livestock presence and remoteness could imply favourable conditions for vultures. However, interpretation is complicated by several factors well beyond the scope of this study. For example, the distribution of human activity is clearly significant to Hooded Vultures in West Africa, but the interaction is less clear-cut for larger species. It is possible that road counts could lead to slightly inflated vulture counts if livestock owners tend to move animals along corridors determined by vehicle routes, or perhaps more likely, vehicle routes have become established along traditional livestock routes between population centres. If so, over many years these may have been preferentially patrolled by foraging vultures. Observations of vultures might be further reinforced as they evidently take advantage of pools that form in roadside borrow pits, themselves the product of road-building. If such positive bias is operating, it would not affect the results of data comparing different road counts, but might affect comparison between 'on-road' and 'off-road' elements.

Our results confirm that Sahelian grasslands still constitute breeding habitat for the two largest species, Rüppell's and Lappet-faced Vultures. Although at one stage doubted (Mundy *et al.* 1992), tree-nesting by Rüppell's Vulture in Chad

Figure 14. Rüppell's Vultures *Gyps rueppelli* at camel carcass, Termit, Niger, November 2008 (Thomas Rabeil)

Vautours de Rüppell *Gyps rueppelli* sur une carcasse de dromadaire, Termit, Niger, novembre 2008 (Thomas Rabeil)

Figure 15. Lappet-faced *Torgos tracheliotos* and Rüppell's Vultures *Gyps rueppelli* at cow carcass, Bahr Al Ghazal, Chad, September 2011 (Tim Wacher)

Vautours oricou *Torgos tracheliotos* et de Rüppell *Gyps rueppelli* sur une carcasse de vache, Bahr Al Ghazal, Tchad, septembre 2011 (Tim Wacher)

was first reported by Salvan (1968) and has since been consistently reported from the Sahel in general (Newby 1979, Morel & Morel 1990, Kemp 1994, Sørensen *et al.* 1996; W. Mullié pers. comm.). Tree-nesting by Rüppell's Vulture has been documented in detail, at W National Park in Niger, by Rondeau *et al.* (2006). We photographed downy young tended by adult Rüppell's Vultures in at least 14 tree nests. As at W National Park, this eliminates the possibility that they were only using the nests of other species for roosting. We also confirmed Rüppell's Vultures at typical cliff-face situations in Chad as reported by Scholte (1998), although we did not investigate nesting behaviour in these cases.

Where conditions are favourable, such as the Termit Massif, Lappet-faced Vultures nest in clusters. Observations at Gadabeji and in OROAGR suggest tree-nesting Rüppell's Vulture also show local clustering. Lappet-faced Vulture is considered a solitary or 'territorial' nester, with mean nest spacing of 3.2 km (Zimbabwe) to 4.2 km (Serengeti), although closer spacing occurs where 'the species is abundant' in Chad (Shimelis *et al.* 2005). Tree nest spacing of 3–4 km is also typical in Saudi Arabia (Shobrak 2011). Tree availability is clearly a significant factor at Termit, as there are almost no trees in the surrounding desert away from the massif. But, while spacing is influenced by nest site availability (as it is for cliff colonies), the observed spacing at Termit is notable in that it enables the vultures to establish visual contact with neighbouring pairs as soon as they rise to forage. This is also true in Gadabeji and OROAGR, where some nests are in sight of each other at ground level. The efficient establishment of a search network has long been assumed to be an important feature of vulture foraging behaviour (Jackson *et al.* 2008) and we speculate that it might also be an important aspect of tree-nest selection for both species in the Sahel.

Our data suggest the possibility of differing preference in nest-tree species selection by two vulture species, with Rüppell's Vulture perhaps preferring *Balanites aegyptiaca* relative to Lappet-faced Vulture (Table 3). However, more detailed information on tree species availability by site is required to test this. Vulture tree nests are also exploited by smaller birds as sources of shade and perhaps insects, while some nest directly below the 'canopy' of the nests. Notably Swallow-tailed Kites *Chelictinia riocourii* were observed nesting directly beneath an active Lappet-faced Vulture nest containing an adult with chick in OROAGR (March 2013) and possibly under a Rüppell's Vulture nest with an adult and chick in Gadabeji (March 2010).

A close association between vultures and human activity in the Sahel through high reliance on livestock carcasses has been noted (Scholte 1998) and examples of livestock being significant attractors of vultures have recently been demonstrated at large scales with satellite-tracking of White-backed Vultures in southern

Figure 16. Rüppell's *Gyps rueppelli*, Hooded *Necrosyrtes monachus* and Lappet-faced Vultures *Torgos tracheliotos* at donkey carcass, Bahr Al Ghazal, Chad, September 2011 (Tim Wacher)

Vautours de Rüppell *Gyps rueppelli*, charognard *Necrosyrtes monachus* et oricou *Torgos tracheliotos* sur une carcasse d'âne, Bahr Al Ghazal, Tchad, septembre 2011 (Tim Wacher)

Figure 17. Lappet-faced Vultures *Torgos tracheliotos* at man-made well, Termit Massif, November 2007 (John Newby)

Vautours oricou *Torgos tracheliotos* près d'un puits traditionnel, Massif de Termit, novembre 2007 (John Newby)

Africa (Phipps *et al.* 2013). In this study, vultures were observed at carcasses on 21 occasions—sheep or goats in six cases, camels seven times (Fig. 14), cows four times (Fig. 15), donkeys three times (Fig. 16), and a Dorcas Gazelle once. It is possible that large livestock carcasses are more likely to attract observer attention, leading to over representation compared to smaller food items. However, livestock are generally far more abundant than wildlife and these figures further indicate that livestock are very important to vultures in this region. Corrected for differences in body size (using typical live weights of adults of each food species), livestock potentially contributed more than 99% by mass to vulture food sources. In nearly all surveys both Rüppell's and Lappet-faced Vultures were observed drinking at wells, sometimes using crude metal troughs filled by hand, but mostly from the associated spillage (Fig. 17). Further south, all six species have been noted at temporary pools in roadside borrow pits. Thus, opportunities for exposure to human activity are many, including to veterinary products in carcasses, rubbish around wells and roadsides, and general hunting risk from simple proximity and exposure on easily approached tree nests.

The main reason for plummeting vulture numbers in South Asia has been ascribed to renal failure as a direct side effect of ingesting the widely used veterinary anti-inflammatory drug, Diclofenac, at livestock carcasses (Oaks *et al.* 2004). Information on the prevalence of these drugs is less well established in West Africa and underlying causes of decline generally poorly known. Large stones were observed in nine vulture nests (11% of all known nests) at Termit and the same phenomenon has been recorded in Saudi Arabia (Shobrak 2011). In both cases this has been attributed to intentional destruction by people. Rondeau & Thiollay (2004) review potential causes of decline in West Africa, including speculation on possible changes in carcass availability (balance between growing numbers of livestock but improved management of carcass disposal) and indirect poisoning during predator control or use of pesticides. Vulture persecution and collection for meat or the traditional medicine market is also noted in some parts of the Sahel (see Nikolaus 2001, Ogada *et al.* 2011). Vulture grease, brains, heads, feet and feathers are still widely used as cures for rheumatism and diarrhoea, as well as in various powders and potions to increase clairvoyance (JN pers. obs.). Finally, the impact of recreational rock climbing by tourists was considered in relation to cliff-nesting colonies of Rüppell's Vulture in Mali and western Niger (Rondeau & Thiollay 2004) and it is evident that these activities occur at a low level in Chad also, though no interaction with vulture colonies has been noted.

In summary, our surveys provide baseline information on vulture distribution across a large zone rarely visited by ornithologists. At the broadest level, encounter rates were similar to those of earlier surveys on a similar scale and at similar latitudes to the west. Our observations also demonstrate that tree-nesting by Rüppell's Vulture is widespread across the Sahel. Although this greatly enlarges the species' potential breeding range, the relative importance and success rates for tree-nesting Rüppell's Vultures (compared to cliff-nesting birds) are unknown. It is also interesting to speculate whether young that fledge from tree nests show any nest-site preference as adults. Only targeted surveys during the nesting period (January–March) and long-term studies can resolve these questions. It is encouraging there is a significant breeding population of Lappet-faced Vultures centred on the Termit Massif, which is now officially protected, with a newly formed team of community rangers active in promoting wildlife protection. Breeding by at least two, probably three, vulture species in the small but comparatively long-established reserve of Gadabeji in Niger, and in the very large Ouadi Rimé-Ouadi Achim reserve in Chad provides further evidence that protected areas are also important for vultures in the Sahel, as already noted for the West African Sudan zone (Thiollay 2006b). Our results also emphasise the degree to which the fortunes of these large, slow-breeding species are tied to human activities and attitudes. In addition to eliminating the practice of poisoning carcasses, whether deliberately for predator 'control' or inadvertently via unsuitable veterinary products, protection of these species would benefit from promoting the view that vultures are of greatest value to the community alive. As noted by Ogada *et al.* (2012), they provide an effective and free sanitation service, probably diminish potential disease reservoirs for people, livestock and wildlife, and contribute to the optimal functioning of a fragile ecosystem.

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